INFLUENCE OF PRE- AND POST-PARTUM NUTRITION ON LH SECRETION IN SUCKLED POSTPARTUM BEEF HEIFERS[a]

S. E. Echternkamp, C. L. Ferrell and J. D. Rone[b]
U.S. Department of Agriculture, Science and Education, Agricultural Research Service, Roman L. Hruska US Meat Animal Research Center, Clay Center, NE 68933

Received for publication: March 22, 1982
Accepted: July 7, 1982

Abstract

The influence of nutrition during the last trimester of pregnancy and the early postpartum period on postpartum LH secretion was evaluated in two-year-old Hereford and Simmental heifers maintained on a high or low plane of nutrition (experiment 1) or in Hereford heifers fed a high or low energy (150% vs 100% NRC) ration (experiment 2). Amount of LH released with 10 mg estradiol benzoate (IM) at 14 and 28 days postpartum in experiment 1 or at 14,32,50 and 74 days postpartum in experiment 2 was less ($P<.01$) for heifers fed the low vs high plane or energy ration and less ($P<.05$) at 14 days postpartum than at subsequent postpartum periods. The interval from estradiol benzoate injection to the LH peak concentration was longer ($P<.05$) in Simmental than Hereford heifers, longer ($P<.05$) in heifers fed the low rather than high energy ration, and longer ($P<.01$) at 14 days postpartum than at subsequent postpartum periods. The amount of LH released was inversely related to the time required for initiation of the release ($r = -.62$). Tonic LH secretion was higher ($P<.05$) in heifers fed the high energy ration and was correlated with average daily gain ($r = .75$), but was unaffected ($P>.05$) by days postpartum or breed of cattle. Results indicate that increased dietary energy intake increases LH secretion and shortens the anovulatory period in suckled postpartum beef heifers.

Introduction

The re-establishment of estrous cycles and fertility in postpartum beef cows is partially dependent on the nutritional regime. A review of the literature indicates a discrepancy as to what constitutes an appropriate nutritional regime for the postpartum cow because of the poorly defined effects of factors such as stage of lactation, suckling intensity, quantity and composition of milk produced, breed of dam and calf, age of dam or a combination of these factors on nutritional requirements. Several investigators have

---

(a) The authors are grateful to William McKay, Fred Philips and LeRoy Hassler for technical assistance; to Michael Buschow, Kathy Sorensen and Ronda Jaeger for assistance with surgery, blood collection and animal care; and to Sherilyn Hansen for manuscript preparation. Cooperation of the Nebraska Experiment Station, University of Nebraska, Lincoln is acknowledged.

(b) Department of Food Science, Clemson University, Clemson, SC 29631.

provided evidence for a direct and/or indirect role for gonadotropins in the re-initiation of estrous cycles in the postpartum cow (1,2,3,4,5). Since suckled postpartum cows fed ≤ 75% of the NRC recommendation for dietary energy (6) have less follicular development (7) and longer postpartum anestrous periods (7,8,9,10) than cows fed 100% NRC, gonadotropin secretion may be decreased in the underfed cows (8) as a result of a direct nutritional effect on the hypothalamo-pituitary-gonadal axis or an indirect negative effect of increased physiological stress on gonadotropin secretion or a combination of both. The objective of the present experiments was to evaluate the influence of pre- and post-partum nutrition on LH secretion in suckled postpartum beef heifers.

Materials and Methods

Experiment 1: Pregnant two-year-old Hereford and Simmental heifers (n=26/breed) were maintained on either a low (10/breed) or high (16/breed) plane of nutrition for the last trimester of pregnancy and 2 weeks postpartum, at which time heifers on the low plane were transferred to the high plane of nutrition. The 16 Hereford and 16 Simmental heifers on the high plane of nutrition were fed *ad libitum* a diet composed of 73.6% alfalfa haylage and 25.6% corn (dry matter basis) plus vitamin and mineral supplementation to provide NRC recommendations for pregnant heifers. The 10 Hereford and 10 Simmental heifers on the low plane of nutriton were fed unsupplemented alfalfa haylage at a dry matter rate of 1.3% of body weight (approximately 5.3 kg/day dry matter for Herefords and 5.7 kg/day dry matter for Simmentals). The low diet provided 100% of the total protein requirement and 70% of the energy requirement for the last trimester of pregnancy and 60% of the energy requirement for an early postpartum lactating cow. The heifers were housed in open-front buildings (May through November) in groups of four to five animals per pen and were fed once a day. The heifers were weighed at 28-day intervals prepartum, within 24 hours after parturition, and at 14-day intervals postpartum.

To evaluate the influence of plane of nutrition on the quantity of releasable LH in the pituitary of suckled postpartum beef heifers, five Hereford and five Simmental heifers from both the low and high plane of nutrition groups were given a single intramuscular injection of 10 mg estradiol benzoate in corn oil at either 2 or 4 weeks postpartum. The 10 mg dosage of estradiol benzoate was selected because of a previous report (11) that 10 mg of estradiol-β mediated an LH release at 2 and 4 weeks postpartum in nonsuckled cows but only at 4 weeks postpartum in suckled cows suggesting that 10 mg approaches the minimal effective dosage for LH release in early postpartum suckled cows. Each heifer was treated at only one postpartum interval. Jugular vein blood (10 ml) for LH measurement was collected by venipuncture at 3-hour intervals from 0 through 33 hours post-estradiol benzoate injection. Blood was collected into heparinized syringes, refrigerated, and centrifuged; plasma was stored at -10C until assayed for LH. A control group, consisting of three contemporary heifers from each breed on the high plane of nutrition, was injected with vehicle only and blood sampled by the same protocol.

Experiment 2: Thirty-two pregnant, two-year-old Hereford heifers were randomly assigned to receive either a maintenance (100% NRC) or a high energy (150% NRC) ration for the last trimester of pregnancy and for 24,42,60 or 84 days postpartum, times at which four heifers from each energy group were removed from the experiment. The maintenance diet was composed of 73.4% corn silage and 26.6% alfalfa haylage (dry matter basis) plus vitamin and mineral supplementation according to NRC recommendations and was fed at a rate to produce an average daily gain (ADG) of .3 kg/head/day prepartum and 0 kg postpartum. The high energy diet was composed of 42.6% corn silage, 14.9% alfalfa haylage and 42.6% corn plus vitamin and mineral supplements and was fed at a rate to produce an ADG of 1.0 kg prepartum and .7 kg postpartum. The heifers were housed in open-front buildings (May through November) in groups of 4 animals per pen and fed individually by the aid of electronic head gates. The heifers were weighed at 28-day intervals prepartum, within 24 hours after parturition, and at 14-day intervals postpartum.

As dictated by a concurrent experiment (12), four heifers from both the low and high energy ration groups were ovariectomized at either 10,28,46 or 70 days postpartum; gross morphology of the ovaries was recorded. Four days after ovariectomy, each heifer received an indwelling jugular vein cannula and a single intramuscular injection of 10 mg estradiol benzoate in corn oil. Blood samples (10 ml) were collected at 2-hr intervals from 0 through 40 hours post-estradiol benzoate injection to determine whether level of dietary energy intake influenced the quantity of estrogen-releasable LH in the pituitary of suckled postpartum heifers. To evaluate in the same heifers the influence of dietary energy intake on tonic LH secretion, as mediated through the postcastration LH response 14 days after ovariectomy, serial blood samples (10 ml) were collected at 10-min intervals for 4 hr via an indwelling jugular vein cannula. Blood samples were processed and stored as in experiment 1. Each heifer was treated with estradiol benzoate and serial blood samples were taken at only one of the four postpartum intervals.

Six nonparous two-year-old heifers that had been ovariectomized for 60 to 120 days were designated as controls. Serial blood samples were collected at 10-min intervals for 4 hr via an indwelling jugular vein cannula. On the subsequent day, the control heifers were given a single intramuscular injection of 10 mg estradiol benzoate. Blood samples were collected at 2-hr intervals for 40 hr, processed and analyzed according to protocols for the postpartum heifers. Control heifers were fed the same ration as the high energy postpartum heifers.

LH Assay: Plasma LH concentrations were determined by use of the double antibody radioimmunoassay for bovine LH (3,13). The LH antisera (DJB 3-12/11) was used at a dilution of 1:40,000 and bound 40-45% of the ^{125}I-labelled LH (LER-1056 C2). The ovine anti-rabbit γ-globulin was used at a dilution of 1:120. Each plasma sample was assayed in duplicates of .2 ml; coefficient of variation of the mean was <10% or the plasma sample was reassayed. The LH results are expressed as ng NIH-LH-B8/ml of peripheral plasma. A low and high LH pool were included in each LH assay, and had mean LH concentrations and coefficient of variations of 2.2 and 62.9 ng/ml and 7.3 and 11.4%, respectively. In experiment 2, basal plasma LH concentration for individual heifers was defined as the mean of the three lowest nonconsecutive LH concentrations or the nadir of three pulsatile LH releases occurring during the 4-hr sampling period. Mean plasma LH concentration for individual heifers was the mean for all 25 samples collected during the 4-hr period. Pulsatile LH releases within individual heifers were defined as increases in plasma LH concentration during the 4-hr sampling period that exceeded the sensitivity of the LH assay and two standard deviations (animal mean) above the basal LH concentration and exhibited a disappearance curve.

Statistics: Data from experiments 1 and 2 were analyzed separately by least-squares analysis of variance (14) and Duncan's multiple-range test (15) to determine the effects of diet, days postpartum, breed (experiment 1), and their interaction on tonic plasma LH concentration, magnitude of the estrogen-mediated LH release, and interval from estradiol benzoate injection to LH peak. Evaluation of the magnitude of the estrogen-mediated LH release as area of the peak or peak LH concentration gave the same results and trends so only peak LH concentrations were reported. Within animal correlations were calculated in experiment 2 for the low and high energy groups and for diet groups pooled using the following response variables: pre-estradiol benzoate plasma LH concentration, maximum LH concentration mediated by estradiol benzoate, interval from estradiol benzoate injection to maximum LH peak concentration, and basal and mean plasma LH concentration 14 days after ovariectomy. Because of large within and among animal variation in body weight for the first two postpartum 14-day weigh periods (experiment 2), the correlation between ADG and plasma LH concentrations was calculated for only the eight heifers per diet that were on the postpartum rations a minimum of 60 days.

Results

Experiment 1: Average daily gains for both the pre- and post-partum periods are contained in Table 1. Heifers on the high plane of nutrition were in a positive weight gain status during both the pre- and post-partum periods. Heifers on the low plane of nutrition also gained weight during the prepartum period, however, when the weight increase associated with fetal and placental growth was subtracted (6), the maternal system was in a negative weight gain status during both the last trimester of pregnancy and the first 14 days postpartum. A portion of the increase in ADG between 14 and 28 days postpartum for the heifers that were transferred from the low to high plane of nutrition resulted from a two-fold increase in daily dry matter intake.

Table 2 contains the mean ($\pm$ standard errors of the mean) plasma LH concentrations immediately before the estradiol benzoate injection (initial LH concentration) and maximum plasma LH concentration mediated by the estrogen. LH surges, LH concentrations $\geq$ two standard deviations above the mean were not detected in heifers that received corn oil alone so control heifers were not included in Table 2. Initial, or tonic, plasma LH concentrations were not affected ($P>.05$) by nutrition, weeks postpartum or breed of cattle. Maximum LH concentration for the estrogen-mediated release was affected by both diet ($P<.05$) and weeks postpartum ($P<.01$); higher LH concentrations for heifers on the high plane than low plane of nutrition, and higher LH concentrations at 4 than at 2 weeks postpartum.

Interval from estradiol benzoate injection to maximum LH peak concentration (Table 2) was longer at 2 than 4 weeks postpartum

(26.4±.9 vs 22.5±.9 hr, P<.01) and for Simmental than Hereford heifers (25.8±.9 vs 23.0±.9 hr, P<.05), but was not affected (P>.05) by plane of nutrition (23.4±.8 vs 25.5±.8).

TABLE 1. AVERAGE DAILY GAIN DURING THE LAST TRIMESTER OF PREGNANCY AND THE EARLY POSTPARTUM PERIOD[a]

Status	Breed	Plane of Nutrition Low (kg)	Low-High[b] (kg)	High (kg)
Experiment 1				
Pre-partum				
	Hereford	.29±.06		.94±.09
	Simmental	.24±.08		.89±.12
Post-partum 0-2 weeks				
	Hereford	-.58±.62		.80±.57
	Simmental	-1.40±.30		1.44±.24
2-4 weeks				
	Hereford		3.41±.59	1.30±.52
	Simmental		2.67±.73	.90±.91
Experiment 2[c]				
Pre-partum				
	Hereford	.21±.05		1.17±.05
Post-partum 0-8 weeks				
	Hereford	-.17±.11		.70±.11

a Heifers were weighed at 28-day intervals prepartum and at 14-day intervals postpartum. Mean ± SEM.
b Heifers on the low plane of nutrition were transferred to the high plane of nutrition at 2 weeks postpartum.
c Average daily gain prepartum was determined for all 16 heifers per dietary energy group, whereas postpartum average daily gain was determined for heifers on the diet a minimum of 60 days postpartum (n=8/group).

Experiment 2: Heifers fed the high energy ration had larger pre- and post-partum ADG (P<.01, Table 1), a higher incidence of ovulation by 46 days postpartum (Table 3), and higher plasma LH concentrations pre- and post-estradiol benzoate treatment at 14, 32, 50 and 74 days postpartum (P<.01, Table 3) than heifers fed the low energy ration. Magnitude of the estrogen-mediated LH peak was not related (P>.05) to pre-treatment LH concentration in heifers fed either the high (r = .10) or low (r = .42) energy rations.

As in experiment 1, heifers fed the high energy ration were in a positive weight gain status during both the pre- and post-partum periods, whereas heifers fed the low energy ration approached main-

TABLE 2. EFFECT OF NUTRITION ON ESTROGEN-MEDIATED LH RELEASE IN POSTPARTUM BEEF HEIFERS[a]

Postpartum interval	No. of heifers	Plane of Nutrition Low	Low-high[b]	High	Overall
Initial LH concentration (ng/ml)					
2 weeks	10	2.0 ± .3		1.8 ± .3	1.9 ± .2
4 weeks	10		1.4 ± .3	1.7 ± .3	1.6 ± .2
LH peak height (ng/ml)					
2 weeks	10	26.1 ± 9.4[c]		66.7 ± 9.4[d]	46.4 ± 6.5[g]
4 weeks	10		86.6 ± 9.4[d]	72.3 ± 9.4[d]	79.5 ± 6.5[h]
Response interval (hr)					
2 weeks	10	24.0 ± 1.3[ef]		28.8 ± 1.3[e]	26.4 ± .9[g]
4 weeks	10		22.8 ± 1.3[f]	22.2 ± 1.3[f]	22.5 ± .9[h]

[a] Heifers received 10 mg estradiol benzoate IM at either 2 or 4 weeks postpartum and jugular vein blood samples were collected at 3-hr intervals for 33 hr for LH quantitation. Mean ± SEM for 10 heifers per plane of nutrition.

[b] Heifers on the low plane of nutrition were transferred to the high plane of nutrition at 2 weeks postpartum.

[cdef] Different superscripts denote significance within a parameter; c and d at P<.01, e and f at P<.05.

[gh] Different superscripts denote significance between overall means within a parameter at P<.05.

tenance of maternal body weight. Average daily gain for the first 60 days postpartum (n=8 heifers per ration) was positively correlated with plasma LH concentration pre-estradiol benzoate treatment (low energy, r=.79, P<.05; high energy, r=.81, P<.05; pooled, r=.75, P<.01), but nonsignificantly (P>.05) with maximum LH concentration post-estradiol benzoate (pooled, r=.06). Also, ADG was positively correlated (r=.54, P<.05) with basal plasma LH concentration 14 days after ovariectomy for the two diets pooled.

The interval from estradiol benzoate injection to maximum LH peak concentration (Table 3) was longer (P<.05) in heifers fed the low vs high energy ration (25.5 ± .7 vs 23.5 ± .7 hr), and was inversely related to the maximum LH peak concentration in heifers fed the low energy ration (r=-.76, P<.01) and to a lesser extent in heifers fed the high energy ration (r= -.45, P>.05) when days postpartum were

TABLE 3. EFFECT OF DIETARY ENERGY INTAKE ON OVULATION AND LH RELEASE IN SUCKLED POSTPARTUM BEEF HEIFERS[a]

Day Post-partum	Dietary energy intake	n	No. ovulated[b]	Initial LH conc.	Estrogen-mediated LH peak	Response interval[c]
				(ng/ml)	(ng/ml)	(hr)
Day 14	Low	4	0	2.0±.4	32.8±13.8	32.0±1.3
	High	4	0	3.3±.4	53.9±13.8	26.8±1.3
	Mean			2.6±.3	43.3± 9.8^{d}	29.4± .9^{d}
Day 32	Low	4	0	2.0±.4	66.5±13.8	24.0±1.3
	High	4	0	2.9±.4	93.0±13.8	21.3±1.3
	Mean			2.5±.3	79.7± 9.8^{e}	22.6± .9^{e}
Day 50	Low	4	0	2.2±.4	58.7±13.8	23.3±1.3
	High	4	4	3.7±.4	109.2±13.8	22.5±1.3
	Mean			2.9±.3	83.9± 9.8^{e}	22.9± .9^{e}
Day 74	Low	4	2	3.1±.4	74.5±13.8	22.5±1.3
	High	4	4	3.4±.4	109.2±13.8	23.5±1.3
	Mean			3.3±.3	91.9± 9.8^{e}	23.0± .9^{e}
Overall	Low	16	2	2.3±.2^{f}	58.1±6.9^{f}	25.5± .7^{h}
	High	16	8	3.3±.2^{g}	91.3±6.9^{g}	23.5± .7^{i}
Control		6		5.0±.4	98.8±3.9	20.0± .9

[a] Four heifers from the high and low dietary energy groups received 10mg estradiol benzoate IM on either Day 14,32,50 or 74 postpartum (4 days after ovariectomy) and jugular vein blood samples were collected at 3-hr intervals 0 through 33 hr for LH quantitation. Mean ± SEM.

[b] Number of heifers that had ovulated at ovariectomy 4 days prior to estradiol benzoate treatment.

[c] Hours between time of estradiol benzoate injection and maximum concentration for the estradiol benzoate-mediated LH release.

[de] Different superscripts denote differences ($P<.01$) associated with days postpartum.

[fg] Superscripts denote significant differences related to dietary energy intake at $P<.01$.

[hi] Superscripts denote significance at $P<.05$.

TABLE 4. EFFECT OF DIETARY ENERGY INTAKE ON LH RESPONSE TO OVARIECTOMY[a]

Parameters	Dietary energy intake High	Dietary energy intake Low
Day 24 postpartum		
Basal plasma LH conc. (ng/ml)[b]	2.1± .3	1.5± .3
Mean plasma LH conc. (ng/ml)[c]	2.3± .6	1.9± .6
Number of LH pulses/4 hr	1.3	.8
Magnitude of pulses (ng/ml)[d]	2.9±1.1	2.2±1.1
Day 42 postpartum		
Basal plasma LH conc. (ng/ml)	1.9± .3	2.0± .3
Mean plasma LH conc. (ng/ml)	2.5± .6	2.3± .6
Number of pulses/4 hr	1.8	.5
Magnitude of pulses (ng/ml)	2.7±1.1	2.7±1.1
Day 60 postpartum		
Basal plasma LH conc. (ng/ml)	2.6± .3	1.7± .3
Mean plasma LH conc. (ng/ml)	4.6± .6	2.1± .6
Number of pulses/4 hr	2.8	1.3
Magnitude of pulses (ng/ml)	10.7±1.1	2.8±1.1
Day 84 postpartum		
Basal plasma LH conc. (ng/ml)	2.6± .3	2.2± .3
Mean plasma LH conc. (ng/ml)	4.0± .6	3.0± .6
Number of pulses/4 hr	2.5	1.8
Magnitude of pulses (ng/ml)	10.9±1.1	5.7±1.1
Overall		
Basal plasma LH conc. (ng/ml)	2.3± .1[e]	1.9±.1
Mean plasma LH conc. (ng/ml)	3.3± .3[e]	2.3±.3
Number of pulses/4 hr	2.1	1.1
Magnitude of pulses (ng/ml)	7.0± .6	3.6±.6
Control heifers		
Basal plasma LH conc.	4.4± .2	
Mean plasma LH conc.	6.4± .3	
Number of pulses/4 hr	3.5	
Magnitude of pulses (ng/ml)	13.8±1.8	

[a] Four heifers from the high and low energy groups were ovariectomized on Day 10,28,46 or 70 postpartum and serial jugular vein blood samples were collected 14 days after ovariectomy at 10-min intervals for 4 hr.

[b,c] Basal and mean (± SEM) plasma LH concentrations (conc.) are defined in the Materials and Methods.

[d] Mean ± SEM of the LH pulse peak conc. for heifers in which pulsatile LH releases were detected.

[e] Denotes differences ($P<.05$) in basal and mean plasma LH conc. associated with dietary energy intake.

pooled. Without Day 14 postpartum heifers, the correlations were r= -.82 (P<.01) for the low and r= -.22 (P>.05) for the high energy ration.

Basal and mean plasma LH concentrations 14 days after ovariectomy (Table 4) were higher (P<.05) at all four postpartum periods (Day 24,42,60 and 84) for heifers fed the high energy ration. The 4-hr LH profiles (Figure 1) 14 days after ovariectomy showed a higher frequency and amplitude for spontaneous pulsatile LH releases in heifers that had ovulated prior to ovariectomy than in those that had not ovulated. Because of the increased incidence of ovulation in the high energy groups, pulsatile LH releases at 14 days after ovariectomy were more prevalent in the heifers fed the high energy ration.

Days postpartum significantly (P<.01) affected both the time required to initiate and the magnitude of the estrogen-mediated LH release (Table 3), but had no effect (P>.05) on plasma LH concentration pre-estradiol benzoate treatment (Table 3) or at 14 days after ovariectomy (Table 4); the maximum LH peak concentration occurred later with a lower magnitude at 14 days than at 32, 50 or 74 days postpartum.

DISCUSSION

Results from these experiments suggest that LH secretion was enhanced in suckled early postpartum beef heifers fed a high energy ration that resulted in positive weight gains during both the pre- and post-partum periods in comparison to heifers fed a low energy ration that approached maintenance of maternal body weight. The increased LH response associated with dietary energy intake was revealed in greater maximum LH release mediated by 10 mg of estradiol benzoate (experiment 1 & 2), shorter intervals from estradiol benzoate injection to maximum LH peak concentration (experiment 2), and higher tonic plasma LH concentrations (experiment 2) in heifers fed the high than low energy rations. A positive relationship between dietary energy intake and tonic LH secretion was further supported by the positive correlation between ADG (0 to 60 days postpartum) and tonic plasma LH concentration (initial LH concentration at 50 and 74 days postpartum and basal plasma LH concentration at 60 and 84 days postpartum). The increased magnitude in estrogen-mediated LH release at 14 days postpartum (experiment 1 & 2) in heifers fed the higher energy ration may be associated with prepartum dietary energy intake since prepartum dietary energy intake has been shown to influence the amount of LH released by exogenous GnRH in suckled postpartum ewes at 5 days, but not at 25 days postpartum (16). However, it is doubtful that differences in LH secretion at 32, 50 and 74 days postpartum (experiment 2) between heifers fed the low and high energy rations were influenced by prepartum nutrition alone, but instead were influenced by a combination of pre- and post-partum nutrition or post-partum nutrition alone as suggested by the results from experiment 1. Similarly, postpartum reproductive performance has been shown not to be affected by prepartum dietary energy intake (65 vs 100% NRC) in suckled beef cows that received adequate (100% NRC) postpartum nutrition (17). Tonic plasma LH concentrations were higher in the heifers fed the high vs low energy ration in experiment 2, but not in experiment 1. This apparent discrepancy may have resulted from the heifers being ovariectomized in experiment 2 in that ovariectomy may have magnified dietary differences in tonic LH secretion.

The increased incidence of ovulation in heifers fed the high vs low energy ration is in agreement with previous reports that postpartum follicular development is increased and the interval from parturition to first estrus is shortened as postpartum dietary intake is increased (7,8,9,10). The increased postpartum ovarian activity in suckled cows fed the high energy postpartum ration in the present and earlier studies (7,8,9,10) may be directly or indirectly related to the increased amount of releasable LH and increased tonic LH secretion for the heifers fed the high energy ration. Also, plasma LH profiles (10-min intervals for 4 hr) for heifers that had ovulated prior to ovariectomy at 46 or 70 days postpartum (higher percentage from the high energy ration groups) were characterized by an increased frequency and magnitude of spontaneous pulsatile LH releases. Whether the earlier appearance and increased magnitude of the pulsatile LH releases in heifers fed the high energy ration hastened ovulation or were the result of the earlier ovulation could not be determined from the protocol of the present study. Nonsuckled postpartum cows have a shorter postpartum anovulatory period and an increased frequency and magnitude of pulsatile LH releases in comparison to suckled postpartum cows and, consequently, it has been suggested that the increased pulsatile LH secretion hasten ovulation in nonsuckled cows (1,3,5,18). Similarly, the shorter postpartum anovulatory period for the heifers fed the high energy ration may be associated with increased tonic LH secretion as exemplified in the increased magnitude and frequency of LH pulses in heifers that had ovulated and the possibility of such a relationship would warrant further investigation.

The smaller and delayed LH release mediated by estradiol benzoate (experiment 2) or by GnRH (19) in postpartum cows fed a low vs high energy postpartum ration would suggest that both LH synthesis and release were affected by dietary energy intake. Pituitary LH content (20,21,22) and the amount of LH releasable by exogenous GnRH (23,24) or estradiol benzoate (experiment 1 and 2) is low at or immediately after parturition and increases during the early postpartum period. This change in pituitary LH content and release pattern may indicate that the secretion of GnRH and/or the response of the pituitary to positive hormonal stimulation is also lower at parturition and increases during the early postpartum period. Since plasma glucose concentration is positively related to dietary energy intake (7,25) and brain tissue is dependant upon glucose for its energy source, the secretion of hypothalamic releasing hormones may be directly influenced by dietary energy intake (26). Therefore, the decreased LH secretion in heifers fed the low energy ration may reflect decreased hypothalamic secretion of GnRH as a result of lower plasma glucose concentrations. However, as to whether the influence of dietary energy intake is indeed mediated through GnRH secretion by the hypothalamus or through some other mechanism(s) in the hypothalamo-pituitary-gonadal axis that is involved in the transition of the pituitary from the prepartum to the postpartum LH secretory pattern remains to be determined.

The interval from estradiol benzoate injection to maximum LH peak concentration was longer in heifers fed the low vs high energy ration (experiment 2) and in Simmental vs Hereford heifers. Echternkamp (3) reported that the interval from the injection of

2,250 IU pregnant mare's serum gonadotropin to the preovulatory LH surge was longer in Brown Swiss than Angus heifers (68 vs 55 hr) in the presence of similar peripheral preovulatory estradiol concentrations and profiles. Since Simmental and Brown Swiss are dual-purpose breeds and produce more milk than the traditional beef breeds (Hereford and Angus), the delayed LH release in the Simmental and Brown Swiss heifers may have resulted from increased nutritional stress associated with increased milk production and warrants further consideration in the evaluation of nutritional requirements for cows with an increased capacity for milk production.

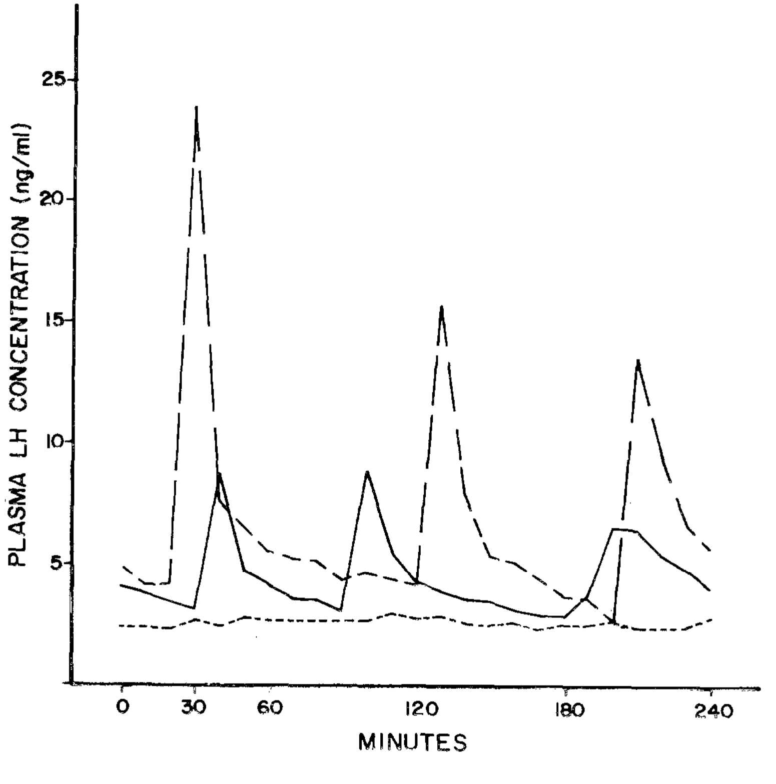

Figure 1. Plasma LH profiles 14 days after ovariectomy for individual Day 84 postpartum heifers on the low energy ration that are representative of heifers that had ovulated (———) or had not ovulated (- - -) on Day 70 postpartum. An LH profile representative of the long term ovariectomized control heifers (— —) is included for comparison.

REFERENCES

1. Echternkamp, S.E. and Hansel, W. Concurrent changes in bovine plasma hormone levels prior to and during the first postpartum estrous cycle, J. Anim. Sci. 37:1362-1370 (1973).

2. Britt, J. H., Kittok, R.J. and Harrison, D.S. Ovulation, estrus and endocrine response after GnRH in early postpartum cows, J. Anim. Sci. 39:915-919 (1974).

3. Echternkamp, S. E. Stimulation of estrogen and luteinizing hormone secretion in postpartum beef cows, J. Anim. Sci. 47:521-531 (1978).

4. Troxel, T.R., Kesler, D.J., Noble, R.C. and Carlin, S.E. Ovulation and reproductive hormones following steroid pretreatment, calf removal and GnRH in postpartum suckled beef cows, J. Anim. Sci. 51:652-659 (1980).

5. Carruthers, T.O. and Hafs, H.D. Suckling and four times daily milking: Influence on ovulation, estrus and serum luteinizing hormone, glucocorticoids, and prolactin in postpartum Holsteins, J. Anim. Sci. 50:919-925 (1980).

6. N.R.C. The Nutrient Requirements of Domestic Animals. No. 4. Nutrient Requirements of Beef Cattle. National Research Council, Washington, DC. 1976.

7. Oxenreider, S.L. and Wagner, W.C. Effect of lactation and energy intake on postpartum ovarian activity in the cow, J. Anim. Sci. 33:1026-1031 (1971).

8. Wiltbank, J.N., Rowden, W.W., Ingalls, J.E. and Zimmerman, D.R. Influence of postpartum energy levels on reproductive performance of Hereford cows restricted in energy intake prior to calving, J. Anim. Sci. 23:1049-1053 (1964).

9. Dunn, T.G., Ingalls, J.E., Zimmerman, D.R. and Wiltbank, J.N. Reproductive performance of 2-year-old Hereford and Angus heifers as influenced by pre- and post-calving energy intake, J. Anim. Sci. 29:719-726 (1969).

10. Holness, D.H., Hopley, J.D.H. and Hale, D.H. The effects of plane of nutrition, live weight, temporary weaning and breed on the occurrance of oestrus in beef cows during the postpartum period, Anim. Prod. 26:47-54 (1978).

11. Short, R.E., Randel, R.D., Christensen, D.S. and Bellows, R.A. Effects on E_2 induced LH release in the bovine, J. Anim. Sci. 39:226 (1974).

12. Rone, J.D., Henricks, D.M. and Echternkamp, S.E. The influence of restricted energy intake on pituitary and ovarian hormone secretion in the young individually fed postpartum beef cow, J. Anim. Sci. 55(Suppl.1) (1982).

13. Niswender, G.D., Reichert, L.E. Jr., Midgley, A.R. Jr. and Nalbandov, A.V. Radioimmunoassay for bovine and ovine luteinizing hormone, Endocrinology 84:1166-1173 (1969).

14. Harvey, W.R. Least-squares analysis of data with unequal subclass numbers, U.S.D.A., A.R.S. 20-8 (1960).

15. Steel, R.G.D. and Torrie, J.H. Principles and Procedures of Statistics, McGraw-Hill Book Co., New York, 1960.

16. Sides, G.E., Dunn, T.C. and Kaltenbach, C.C. LH response during GnRH infusion in fall lambing ewes fed different energy levels prepartum, J. Anim. Sci. 51(Suppl 1):329 (1980).

17. Corah, L.R., Dunn, T.G. and Kaltenbach, C.C. Influence of prepartum nutrition on the reproductive performance of beef females and the performance of their progeny, J. Anim. Sci. 41:819-824 (1975).

18. Walters, D.L., Dunn, T.G., and Kaltenbach, C.C. Hormone levels in serum and follicular fluid of beef cows after short-term weaning, J. Anim. Sci. 49(Suppl. 1):344 (1979).

19. Lishman, A.W., Allison, S.M.J., Fogwell, R.L., Butcher, R.L. and Inskeep, E.K. Follicular development and function of induced corpora lutea in under fed postpartum anestrous beef cows, J. Anim. Sci. 48:867-875 (1979).

20. Nalbandov, A.V. and Casida, L.E. Gonadotropic action of pituitaries from pregnant cows, Endocrinology 27:559 (1940).

21. Saiduddin, S., Riesen, J.W., Graves, W.E., Tyler, W.J. and Casida, L.E. Pituitary luteinizing hormone activity in the postpartum cow, J. Anim. Sci. 25:930 (1966).

22. Wagner, W.C., Saatman, R. and Hansel, W. Reproductive physiology of the postpartum cow. II. Pituitary, adrenal and thyroid function, J. Reprod. Fertil. 18:501-508 (1969).

23. Fernandes, L.C., Thatcher, W.W., Wilcox, C.J. and Call, E.P. LH release in response to GnRH during the postpartum period of dairy cows, J. Anim. Sci. 46:443-448 (1978).

24. Irvin, H.J., Garverick, H.A. Zaied, A.A., Kesler, D.J., Day, B.N. and Youngquist, R.S. LH response to GnRH in postpartum suckled beef cows, J. Anim. Sci. 45(Suppl. 1):172 (1977).

25. Patil, J.S. and Deshpande, B.R. Changes in body weight, blood glucose and serum proteins in relation to the appearance of postpartum oestrus in Gir cows. J. Reprod. Fert. 57:525-527 (1979).

26. Howland, R.E., Kirkpatrick, R.L., Pope, A.L. and Casida, L.E. Pituitary and ovarian function in ewes fed on two nutritional levels, J. Anim. Sci. 25:716-721 (1966).